

EMPLOYEE EXPOSURE TO METHYL BROMIDE  
USED FOR GROUND SQUIRREL CONTROL

By

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SUMMARY

Inhalation exposure of employees to methyl bromide was measured during fumigation for control of ground squirrels. Methyl bromide was measured with air samples collected from employee breathing zones. Eight-hour Time-Weighted-Average (TWA) exposures ranged from 0.01 to 0.52 ppm. The Cal/OSHA Permissible Exposure Limit (PEL) is 15 ppm, based upon an 8-hour TWA. Peak exposures, measured with short-duration samples, ranged from none detected (less than 0.02 ppm) to 13.9 ppm. Based on the air sampling data, the work practices monitored do not appear to produce excessive inhalation exposures to methyl bromide when compared to current exposure standards. Recommendations are made to improve employee safety while using methyl bromide for controlling ground squirrels.

## INTRODUCTION

Ground squirrels in California have been reported to cause crop damage in numerous grains, fruits and nuts. Seepage or collapse of levees and ditchbanks can occur from ground squirrels burrowing into these structures. Ground squirrels are also considered hosts to fleas infected with bubonic plague (1). Ground squirrels may be controlled by county, state or federal officials and employees, when acting in their official capacities under the provisions of the Food and Agriculture Code pertaining to pests (1, 2). Burrow fumigation with methyl bromide is one of several methods of ground squirrel control; these include trapping, baits with zinc phosphide, strychnine or anticoagulants, fumigants, carbon disulfide and smoke cartridges (1). Phostoxin (aluminum phosphide) has also been studied as a burrow fumigant (3). Some county agricultural officials report that methyl bromide is more effective in certain circumstances than other toxicants used in ground squirrel control. Squirrels may avoid feeding on baits, or feed preferentially on nearby fruit, nut or grain crops. Soils may not contain sufficient moisture for phosphine gas to be liberated from Phostoxin. Methyl bromide is often considered the last alternative to use when other control measures have proved ineffective.

Methyl bromide is a colorless gas which has no odor or taste at low concentrations. Workers exposed to low concentrations (35 ppm for 2 weeks) described symptoms of nausea, vomiting, headaches, skin lesions and "symptoms of mild systemic poisoning" (4). Central nervous system toxicity is the most prominent effect of occupational exposure to methyl bromide. Symptoms include tremors, twitching, seizures or convulsions; the onset may be delayed from 3 to 36 hours following exposure. Repeated, or chronic exposure can result in ataxia and mental disabilities. Damage to other organs, particularly the lungs and kidneys, has been noted. Methyl bromide is not teratogenic in rats or rabbits at concentrations up to 70 ppm, with 3 weeks of exposure. Methyl bromide has been shown to be mutagenic in an Ames assay (5). It has been shown to be carcinogenic in rats exposed by gavage (6); however, inhalation exposure studies on animals are not yet completed. Skin exposure to methyl bromide results in redness, swelling and blisters (4, 5). The durations and magnitudes of exposures resulting in the effects of methyl bromide are poorly documented. Few measurements have been made of exposure concentrations (4, 5).

Current exposure standards for methyl bromide are: 15 ppm, the Permissible Exposure Limit (PEL), based on an 8-hour Time-Weighted-Average (TWA); 25 ppm, the Excursion Limit, allowed for a single 5-minute period each 8-hour day; and 50 ppm, the Ceiling Limit, the maximum concentration to which an employee may be exposed to at any time (7). These are enforced by the California Division of Occupational Safety and Health (Cal/OSHA). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a Threshold Limit Value (TLV) of 5 ppm, based on an 8-hour TWA, with a Short-Term-Exposure-Limit (STEL) of 15 ppm, based on a 15 minute TWA. Four excursions into concentrations at or below the STEL are permitted each 8-hour day (8).

The California Department of Food and Agriculture has recently proposed worker safety regulations for fumigant uses. When an employee's exposure would exceed the PEL, or the employee is exposed to a fumigant without adequate warning properties, the employer shall either: require the use of

Self-Contained-Breathing-Apparatus (SCBA), employ continuous monitoring to insure that the concentration is below the PEL, or operate under a variance issued by the Department. The Department may issue a variance when the employer demonstrates that employees performing the fumigation in a specific manner are not exposed to concentrations in excess of the PEL (see Appendix One). The purpose of this study was to determine if county agriculture department employees were exposed to methyl bromide concentrations exceeding the PEL. Data from this study will assist county agricultural commissioners in developing a safety program to allow departmental employees to fumigate without the use of SCBA or continuous monitoring.

#### STUDY SITES

Four (4) fumigations were studied in Contra Costa and Merced Counties. In Contra Costa County, 1 fumigator (A) and 1 shoveler (B) were monitored during the first trial. A single employee (B), fumigating and shoveling, was monitored in the second trial. Methyl bromide was supplied in 1.5 lb cans (DOW, EPA Reg. No. 464-3-AA). The application device was composed of a clamp which punctured the can and copper tubing which delivered methyl bromide (through a needle valve) into a rubber hose approximately 2 feet in length. The hose was inserted fully into the hole and buried with a few shovelfuls of soil. The valve is then turned on for 3 to 5 seconds. The valve is turned off, then the hose is removed from the plugged burrow. Depending upon the amount of walking between burrows, 10 to 20 burrows are fumigated every hour.

In Merced County, 1 fumigator (C) and 1 shoveler (D) were monitored during the third trial. Two (2) employees sharing fumigation and shoveling duties (C, E) were monitored during the fourth study. Methyl bromide was supplied in a 50 lb. cylinder (a Special Local Need registration by Merced County, California Reg. No. 11101-50038-AA). The application device is a pressure regulator with a ball valve which dispenses a 20 ml aliquot of liquid methyl bromide through a 6 foot Tygon hose into a 3 foot hollow metal probe. The probe is inserted fully into the burrow and the valve is operated, dispensing methyl bromide into the burrow. The probe is removed, then the burrow is sealed with a few shovelfuls of soil. The work rate (number of holes treated per hour) was similar to that observed in Contra Costa County.

#### MATERIALS AND METHODS

Employee exposures to methyl bromide were measured with air samples. Eight-hour TWA exposures were measured with samples covering injection of methyl bromide and shoveling soil into burrows. Sampling did not cover loading and unloading of equipment, shop maintenance of equipment, or driving to and from the fumigation sites. TWA exposures were calculated according to the formula in Table 1. Short-term exposures, relative to the Cal/OSHA Excursion Limit were measured with 5-minute air samples.

Air samples were collected with battery-powered air pumps, worn by the employees, drawing air through charcoal sampling tubes designed to trap organic vapors. A length of Tygon tubing connected the tube to the pump. The charcoal tube was positioned in the employee's breathing zone. The pumps were calibrated at 75 ml/min. for TWA determination. A separate pump,

calibrated at 1.0 l/min., was used to collect 5-minute air samples. Methyl bromide was desorbed from charcoal using ethyl acetate and analyzed by gas chromatography (9).

Employee exposures relative to the Cal/OSHA Ceiling Limit were measured with direct-reading colorimetric detector tubes (Drager Reference No. 67-28211).

### RESULTS

Employee TWA exposures and the actual concentrations measured are summarized in Table 1. Calculations of TWA's assume that exposure during the unsampled period was zero (except for the first trial where the employees reported working for 3 hours).

Peak exposure concentrations measured with 5-minute air samples are reported in Table 2. During the first and second trials (12/2/83 and 1/5/84 in Contra Costa County), a total of 9 detector tube samples was collected. Six (6) samples were collected from the fumigators' breathing zones while the fumigant was injected into a burrow; all samples detected less than 3 ppm. Three (3) samples were collected at ground level, at the mouth of a plugged burrow following injection; these detected 100, 40 and less than 3 ppm.

### DISCUSSION

Inhalation exposures to methyl bromide were below the PEL based on employees' 8-hour TWA exposure measurements. TWA exposures ranged from 0.01 to 0.52 ppm. Methyl bromide concentrations in short-term (5-minute) air samples ranged from none detected to 13.9 ppm. Concentrations in these samples were below the Excursion Limit. No remarkable differences in methyl bromide concentrations were seen between different job types, or different ambient temperatures (temperatures were approximately 50 F in December and January, and approximately 70 F in March).

The sporadic work rate for burrow fumigation contributed to low employee TWA exposures. Methyl bromide concentrations measured during injection and shoveling (unadjusted to an 8-hour TWA) ranged from 0.04 to 3.25 ppm, with most samples containing greater than 0.5 ppm.

Measurements of methyl bromide concentrations were not made during loading/unloading of equipment, equipment maintenance or commuting to and from fumigation jobs. Substantial methyl bromide exposure could occur during shop maintenance of fumigating equipment, depending on the presence of ventilation controls, precautions taken while disassembling equipment and types of personal protective equipment used.

Potentially hazardous concentrations of methyl bromide could off-gas from fumigated burrows; however, natural dilution ventilation appears to substantially reduce these concentrations before they reach the employee's breathing zone.

Employees did not wear eye protection during fumigation. Droplets of methyl bromide were observed leaking from the probes, following injection, which could be flung into the eyes if a probe was moved abruptly. Methyl bromide

is severely irritating to the eyes, so goggles or a faceshield should be worn (labels for both products state, "do not get in eyes. . .").

The isolation of the work place presents some special health and safety problems. An equipment malfunction releasing high concentrations of gas or liquid methyl bromide could be hazardous to an employee working alone. This hazard could be mitigated by using a "buddy-system" while fumigating, and tracking the employees' locations and itineraries (allowing an overdue employee to be located more quickly). Employees should be trained to recognize the symptoms of and administer first aid for, methyl bromide poisoning. Vehicles used for methyl bromide fumigation should be equipped with decontamination water, in case of eye or skin exposure.

Additional safety precautions should be taken when using pressurized cylinders for the delivery of methyl bromide. Cylinders should be stored and handled in a manner to prevent tipping, falling or rolling. Cylinders should be securely fastened to the hand-trucks used to move them. Employees should use extra care when moving cylinders over uneven terrain (e.g., up the sides of levees). The regulators should be removed and valve covers installed during transportation to and from fumigation jobs. Cylinders should be regularly inspected for leaks and defects.

One (1) 5-minute sample detected 13.9 ppm of methyl bromide, though the TWA determination sample during the same period detected only 0.04 ppm (see results for employee E, 3/28/84). Exposure standards were not exceeded based on this excursion, though the discrepancy between the two measurements is puzzling. This employee should be monitored again to determine if the discrepancy is due to random chance or is the result of an exposure-producing work practice.

### CONCLUSIONS

During this study, employees fumigating squirrel burrows had exposures to methyl bromide which did not exceed any currently enforced or recommended standards. Based on those results, employees performing squirrel control using methyl bromide do not require respiratory protection devices.

An employee safety program for methyl bromide use should incorporate the use of eye protection; training in the recognition of the hazards of and first aid for methyl bromide exposure; appropriate communication provisions and supervision for employees working in isolated areas; and safe handling procedures for pressurized cylinders. Maintenance operations for cylinders or application devices should be monitored to determine if these activities expose employees to excessive concentrations of methyl bromide.

TABLE 1

## Employee 8-hour TWA Exposures to Methyl Bromide

County	Date	Employee	Duties	Sampling a/ Duration (min)	Concentration of Methyl Bromide (ppm)	
					Detected in Sample	TWA b/ Exposure
Contra Costa	12/2/83	A	Fumigator	95	0.58	0.22
		B	Shoveler	100	0.10	0.04
	1/5/84	B	Fumigator/ Shoveler	54	0.55	0.07
Merced	3/12/84	C	Shoveler	65 30	1.18 0.91	0.22
		D	Fumigator	65 30	3.25 1.33	0.52
	3/28/84	E	Fumigator/ Shoveler	95 NA	0.04 NA <sup>c/</sup>	0.01
		D	Fumigator/ Shoveler	95 38	0.74 0.95	0.22

a/ Equals the actual time worked, except for employees monitored 12/2/83.

b/ Calculated as follows:

$$TWA = \frac{C_1 T_1 + C_2 T_2 + \dots + C_n T_n}{8 \text{ hours}}$$

Where C = Concentration in sample (ppm)

T = Sampling Duration (hours)

Exposure during the remainder of the workday is assumed to be zero.

c/ NA means sample not available; lost during collection.

TABLE 2

## Peak Exposures to Methyl Bromide Based on 5-Minute Air Samples

County	Date	Employee	Duties	Concentration of Methyl Bromide (ppm)
Contra Costa	12/2/83	A	Fumigator	0.04
		B	Shoveler	N.D. <sup>a/</sup>
	1/5/84	B	Fumigator/ Shoveler	0.72, 0.91, 1.42
Merced	3/12/84	D	Fumigator	0.35, 0.50, 4.34, 0.86
	3/28/84	D	Fumigator/ Shoveler	0.22, 0.08
		E	Fumigator/ Shoveler	0.07, 13.9

<sup>a/</sup> Means none detected, minimum detectable level is 0.02 ppm.

#### REFERENCES

1. Clark, D.O., Vertebrate Pest Control Handbook. California Department of Food and Agriculture. Unpublished (1975).
2. Food and Agriculture Code, Sections 6021-6024.
3. Salmon, T.P. and W.P. Goranzel. Ground Squirrel Fumigation Trials. University Extension. Unpublished (1980).
4. Documentation of the Threshold Limit Values, 4th Edition. American Conference Governmental Industrial Hygienist (1980).
5. Alexeeff, G.V. and W.W. Kilgore. Methyl Bromide. Residue Reviews 88: 102-153 (1982).
6. Danse, L.H.J.C., F.L. Van Velsen and C.A. Van Der. Heihden. Methyl bromide: Carcinogenic Effects in the Rat Forestomach. Toxicol. Appl. Pharmacol. 72: 262-271 (1984).
7. Title 8, California Administrative Code, Section 5155.
8. Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1983-84. Amer. Conf. Govern. Ind. Hyg. (1983).
9. Methyl Bromide. Method No. S-372. National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods, Second Edition. (1977).



## DEPARTMENT OF FOOD AND AGRICULTURE

ENF 83-51



1220 N Street  
Sacramento  
95814

July 12, 1983

TO: COUNTY AGRICULTURAL COMMISSIONERS

SUBJECT: Proposed Fumigation Regulations

At the conference in South Lake Tahoe, we agreed to make some changes in the proposed fumigation regulation and give you time to review the draft again before we formally propose it. Please review the attached proposed regulation and make comments in writing to Jerry Campbell by mid-August.

Thank you for your assistance and patience with this regulation.

Sincerely

A handwritten signature in dark ink, appearing to read "James W. Wells".

James W. Wells, Chief  
Pesticide Enforcement Unit  
(916) 445-5343

Attachment

PROPOSED NEW SECTIONS FOR USE OF FUMIGANTS:

Section \_\_\_\_\_. Respiratory Protective Equipment. Whenever respiratory protection is required, the equipment shall be that approved by the National Institute for Occupational Safety and Health (NIOSH) and/or Mine Safety and Health Administration (MSHA) for the specific chemical and exposure condition.

Section \_\_\_\_\_. General Fumigation Safe-Use Requirements.

(a) When an employee's exposure would exceed the Permissible Exposure Limit (PEL) as specified in Title 8, California Administrative Code, Section 5515, Airborne Contaminants, the employer shall require the employee to wear respiratory protective equipment.

(b) Whenever an employee is exposed to a fumigant without adequate odor warning properties, the employer shall either: (1) require the use of Self-Contained Breathing Apparatus (SCBA), (2) employ continuous monitoring to assure that the concentration is below the PEL, or (3) operate under a variance issued by the Department. The following fumigants are considered to have adequate odor warning properties to alert workers before concentrations in excess of PEL are encountered and would not require SCBA in routine work practices: Methyl bromide with at least 0.25% chloropicrin added; carbon disulfide, chloropicrin, DDVP, ethylene dichloride, sulfur dioxide, and sulfuryl fluoride in the presence of .25% chloropicrin.

(c) Upon application of an employer, the Department may grant a variance upon a demonstration of a program, method, work practice, device or process which will ensure that employees will not be exposed to concentrations in excess of the PEL.

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Variance for Respiratory Protection  
(Fumigation)

A variance may be granted when the Department determines such variance will meet or exceed the minimum requirements of worker health and safety concerns.

Determination of the minimum health and safety requirements will solely rest with the Worker Health and Safety Unit and be based on at least the following considerations:

- A. The employer or representative shall present, as a minimum, the following facts:
  1. The eight-hour Time Weighted Average (TWA) of workers exposed to specified fumigant(s) during distinct work procedures of the fumigation process.
  2. Short-term exposure concentrations of workers exposed to specified fumigant(s) based on air samples of no more than 15 minutes duration.
  3. Maximum exposure concentrations based on instantaneous readings taken during the most adverse conditions of exposure according to the qualified person administering the monitoring program.
  4. Written work procedures reflecting respiratory protection requirements based on the findings represented in (1), (2), and (3) above.
  5. A separate written procedure that will encompass mitigating measures to be taken during emergencies such as unexpected equipment failure, or worker down in high concentration or similar scenario requiring worker entrance into unknown and/or suspected high concentrations of fumigant gas.
  6. The variance shall be based on at least two replicated surveys. If more than a 10 percent differential of airborne concentrations are recorded, additional monitoring shall be conducted so that the deviation from the mean concentration of each discrete work practice is within a 10 percent envelope of concentration.
- B. All variance applications will be submitted to the Department, Attention: Chief; Worker Health and Safety Unit. The application will be of such form and format that it is clear that: (1) it is a variance application; (2) the requirement of (1) through (6) above are readily apparent; (3) the name, address, and telephone number of the person or firm conducting the monitoring program is readily discernable; and (4) the employer shall certify that all information submitted by him in support of the variance is true and correct. The certification shall be signed by the employer or his authorized agent and shall be dated.

(d) The employer shall have an emergency response plan posted in a prominent place at the worksite, which provides instructions to protect employees during situations such as spills, fire, and leaks.

Section \_\_\_\_\_. Fumigation of Enclosed Spaces.

Enclosed spaces include, but are not limited to, vaults, chambers, greenhouses, vans, boxcars, ships, planes, vehicles, and tarpaulin covered structures.

(a) Whenever a pesticide is used for fumigation of enclosed spaces, at least two trained persons shall be present at all times during introduction of the fumigant, testing, and aeration periods.

(b) Posting requirement. Warning signs stating "Danger-Fumigation" the name of the fumigant, and the date and time fumigant was introduced shall be posted at all entrances to the vault, chamber or other building, on all four sides of any tarpaulin fumigations, and shall remain until aeration is complete.

(c) Employees shall not be allowed to enter fumigated enclosed areas, except to make tests, unless the concentration in the area is known to be at or below the PEL.

(d) The fumigant shall not be purged into the work place of unprotected workers.

(e) After completion of the fumigation, the treated area or products must be managed so that persons entering the area or working with the treated products are not exposed to concentration of the fumigant in excess of the PEL.

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An additional variance application will be required if there are substantial changes made in written work practices, engineering controls (ventilation systems), after repair of any structural damage, or any reportable fumigant-related illness. Ventilation systems shall be tested after initial installation, alterations or maintenance, and at least annually, by accepted means. Records of these tests shall be retained for at least two years and will be made available to County or State inspection representatives upon request.

The Department will act on the variance within 15 working days after receipt of the application. The applicant will be notified in writing of the acceptance of the application or, if not acceptable, the reasons for denying the acceptance. Denial in no way jeopardizes reapplication in a timely manner.

It is the applicant's express duty to inform all affected employees of the accepted variance and to require such employees to adhere to the approved work practices and proper use of personal protective equipment as presented in the variance.

The Pesticide Enforcement Unit and the County Agricultural Commissioner of the county in which the applicant resides, or in which the work site is located, will be notified of any and all approved applications.